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ABSTRACT

This report describes the population of newly enrolled graduate students in physics and astronomy who were at their current institutions for a year or less in fall 1997. The report contains information on student characteristics and explores the decision making process and critical transition points for entering graduate students. The report also voices key aspects of the early graduate student career. In fall 1996, 2,423 first-year physics students and 143 first-year astronomy students entered a graduate program in the United States. Responses from a student survey completed by 1,030 students provided much of the data for this report. Foreign students now comprise half of the first-year student enrollments at graduate physics departments and 30% of the first-year students at astronomy departments. Virtually all of the students in Ph.D. departments receive some type of financial support. More than one-quarter of these students thought that their undergraduate educations had not prepared them adequately for graduate school, and women were twice as likely to feel underprepared. By the end of the first year of graduate study, 23% of students had not decided on a research specialty. Teaching and research in an academic setting were the long-term career goals of 65% of the first-year students . (SLD)

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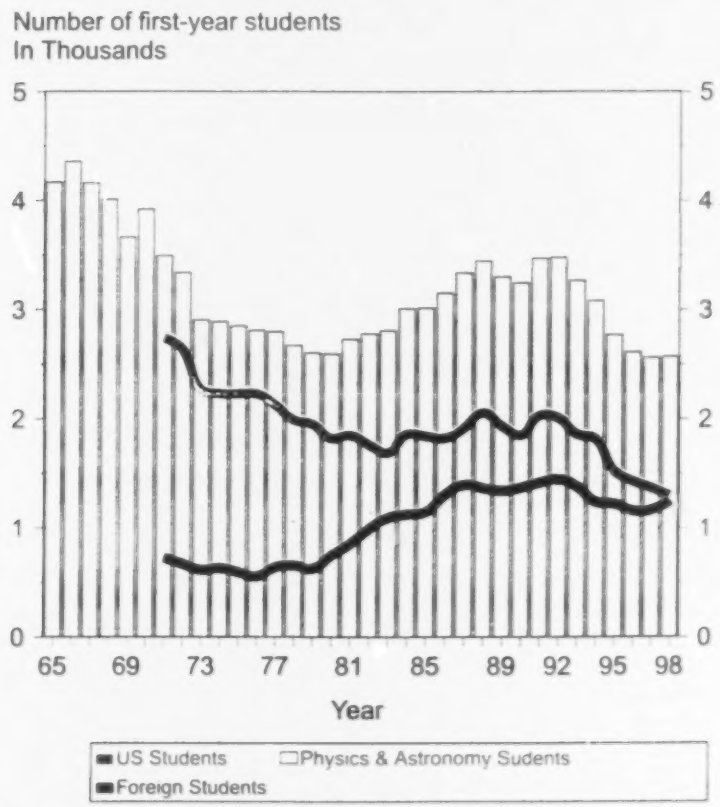
1998 Graduate Student Report: First-Year Students

Figure 1. First-year graduate students in physics and astronomy, 1965-1998.



Note: Starting in 1995 refinement in wording may slightly raise the foreign citizen totals relative to those reported in earlier years. A citizenship breakdown of first-year enrollments is not available prior to the academic year 1970-71.

Source: AIP 1998 Graduate Student Report.

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Highlights

For the purposes of the study, first-year graduate students are defined as students who are completing their first year of study in their current department. It should be noted that 12% of the US students reported having previous graduate-level course work, and that over half of the foreign students indicated degrees or course work beyond the equivalent of a US bachelor's degree at the time they entered a US graduate program (see discussion on **pages 4-5**).

Foreign students now comprise half of the first-year student enrollments at graduate physics departments and 30% of the first-year students enrolled at astronomy departments **(Table 1)**.

Virtually all first-year physics and astronomy students enrolled in PhD departments receive some type of financial support **(Table 8)**.

Over one-quarter of the first-year US students feel that their undergraduate education did not adequately prepare them for graduate school **(Figure 2)**. Women were twice as likely as men to feel underprepared **(Figure 4)**.

The majority of incoming US students first decided to pursue physics or astronomy graduate studies while they were undergraduates **(Table 4)**.

By the end of their first year of graduate study, 23% of the students had not decided upon a research specialty. For the US students who had chosen a specialty, astronomy/astrophysics was the most common selection. Condensed matter was the leading choice for the foreign students **(Table 7)**.

Teaching and/or research in an academic setting was the long term career goal for 65% of first-year US physics and astronomy graduate students **(Figure 5)**.

Introduction

The Statistical Research Center of the American Institute of Physics (**AIP**) has reported on the characteristics and initial employment of physics and astronomy graduate students for over three decades. With the majority of physics graduate students in pursuit of a PhD and the average number of full-time equivalent years to earn that degree being 6.2, the overall characteristics of this group change very slowly. The primary point at which change is introduced is when new students first enter graduate physics and astronomy programs.

In order to gain a better understanding of the composition of and issues concerning this graduate student population, we have opted to focus our survey on incoming students. This report describes the population of newly-enrolled physics and astronomy students who were at their current institution for a year or less in the fall of 1997.

This report describes student characteristics such as gender, citizenship, and educational background. It explores the decision making process and identifies critical transition points for entering graduate students, including: delays between undergraduate schooling and graduate school, the number of departments applied to, and the process of choosing a school to attend. The report also covers key aspects of the early graduate student career, like choosing an advisor and obtaining support. Finally, long term goals, highest intended degree, job market familiarity, and career objectives are examined.

According to the AIP Enrollments and Degrees Survey, in the fall of 1997 (the 1997-98 academic year), 2423 first-year physics students and 143 first-year astronomy students entered a graduate program in the US. The student survey was conducted in the spring of 1998 and sent to students whose names were obtained from the departments in

the fall of 1997. After two mailings, we received usable responses from about 1030 students, representing 40% of the known departmental total. However, we estimate that we did not have suitable mailing addresses for about 30% of our target population, raising the actual survey response rate to over 50%.

As **Figure 1** shows, there recently have been some dramatic changes in the number and citizenship of students enrolling in US physics and astronomy programs. First-year student enrollments have declined 26% since the early 1990's, although they have stabilized during the last couple of years. This drop has been especially pronounced among US citizens. As a result, foreign students comprised half of all students entering physics and astronomy departments in 1997-98. Subsequently, the number of US students enrolling in physics and astronomy departments is the lowest it has been since the Institute started collecting data on citizenship about three decades ago.

The following analysis includes only students enrolled in US degree-granting physics and astronomy departments during the 1997-98 academic year. To be included a student had to be new to the department, meaning that it was his or her first year attending the department at which the students were surveyed. For the purposes of this analysis, students enrolling in separate astronomy departments and in the astronomy portion of a combined physics and astronomy department are considered first-year astronomy students.

CHARACTERISTICS

Except where noted, this report will combine data for both physics and astronomy students. The circumstances and experiences of both groups of incoming students are generally similar. However a few important differences in student characteristics do emerge, as illustrated in **Table 1**. Most notably, the representation of foreign citizens among first-year physics students is much greater than it is among the astronomy students. Physics students also tend to be older than their astronomy counterparts.

Table 1. Characteristics of first-year physics and astronomy graduate students, 1997-98.

	Physics	Astronomy
Sex*		
Male	80%	74%
Female	20	25
Citizenship*		
US	50%	70%
Foreign	50	30
Age		
US Citizens		
23 or younger	48%	58%
24-25	23	24
26 or older	29	18
Foreign Citizens		
23 or younger	11%	20%
24-25	34	30
26 or older	55	50

* Data from the AIP Survey of Enrollments and Degrees

Source: AIP 1998 Graduate Student Report.

Given the increase in foreign students, it is important to look at their countries of origin. After rising rapidly in the late 1980's and early 1990's, the proportion of students coming from China has declined, while the percentage from Eastern and Central Europe has been on the rise. **Table 2** shows the where the 1997-98 first-year, non-US students originated from.

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Table 2. Region/country of origin of first-year physics and astronomy graduate students who were not US citizens, 1997-98.

	Percent
Asia	
People's Republic of China	27
India	7
South Korea	4
Taiwan, Hong Kong	2
Japan	1
Pakistan	1
Other Asia	3
Europe	
Eastern and Central	22
Western	18
Americas	
Mexico, South and Central America	4
Canada	2
Middle East	5
Africa	3
Australia, New Zealand	1

Note: There were 1183 foreign citizens enrolling as first-year students in US graduate programs in 1997-98. The data include students on temporary and permanent visas.

Source: AIP 1998 Graduate Student Report.

EDUCATIONAL BACKGROUND

Determining the level and type of prior study for foreign students is very difficult, due to the vastly differing higher education systems in other countries. For that reason the discussion concerning educational background will focus primarily on the US citizens. Some citizenship comparisons will be attempted using terminology associated with the US education system.

An important component of the educational background for students who ultimately enter a graduate level physics or astronomy program is whether they took a high school physics course. Overall, about 24% of 1993 US high school seniors took a physics course (see **Table 3**). The comparable figure for first-year US graduate physics and astronomy students in 1997-98 was 94%. Clearly, for many individuals, exposure to physics in high school is an important step on the path to future studies in physics or astronomy. A similar filtering process takes place at the undergraduate level. One-third of one percent of the bachelor's degrees in this country are granted in the field of physics or astronomy, but 93% of the US citizens entering physics and astronomy graduate study in 1997-98 had received an undergraduate degree in one of those subjects.

Table 3. Educational background of first-year physics and astronomy graduate students with US citizenship, 1997-98.

Have taken HS Physics:	
All high school seniors in 1993	24%
First-year physics and astronomy graduate students in 1998	93
Earned an undergraduate degree in physics	
All bachelors in 1997	0.3%
First-year physics and astronomy graduate students in 1998	93

Source: AIP 1998 Graduate Student Report.

Practically all of the first-year foreign students indicated they had taken a high school physics course and about 95% have received what could be considered at least the equivalent of a bachelor's degree in physics or astronomy.

Some of the students just entering their current program indicated that they also had received some prior *graduate-level* physics or astronomy training. About 12% of the students with US citizenship reported having had previous graduate coursework, with the majority having earned a master's degree in physics at a different institution. More noteworthy, we estimate that more than half of the foreign students enrolling in US graduate physics programs in 1997-98 entered with more than just the equivalent of a US undergraduate degree; many had what might be considered the equivalent of a US masters degree in physics. Much of this discrepancy in educational background is attributable to the differences between undergraduate programs in the US and undergraduate-equivalent programs abroad, which may cover the physics curriculum in greater depth and require more years to complete.

CHOOSING THE FIELD

Students were asked to recall when they first decided to pursue graduate studies in physics or astronomy. **Table 4** illustrates that the majority of US students make the decision while an undergraduate, whereas foreign students often decided on physics prior to entering college.

Students were asked to rank the major factors influencing their choice of physics or astronomy as their academic specialty. They were given seven choices (see **Table 5**), and the data shown represent the percentages of students who listed a particular influence as one of their 3 most important and the percent that listed an influence as the most important. By far, both US and foreign citizens selected "interest in the subject matter" as the most influential. About three-quarters of the students listed it as the most influential reason, and virtually everyone placed it among their top three. Way down the scale, the second most influential factor for US students was an undergraduate professor, whereas for the foreign students, it was a high school teacher. This divergence of influences by citizenship is in line with the data on the timing of the education decisions seen in Table 4, that showed foreign students tended to choose to pursue graduate studies in physics and astronomy earlier in their academic career.

Table 4. Timing of initial decision to pursue physics and astronomy graduate study, 1997-98.

	US Citizens %	Foreign Citizens %
While an undergraduate	58	42
Pre-college	26	44
After working with a bachelor's degree	11	9
Other	5	5
	100%	100%

Source: AIP 1998 Graduate Student Report.

About one-quarter (28%) of the first-year students studying physics or astronomy indicated that they had also considered other graduate disciplines. Among these students, engineering was by far the most prevalent second choice regardless of citizenship. This was followed by mathematics for the US students and computer science for the non-US students. The reasons given for ultimately choosing physics over these other disciplines centered around the students' attraction to the subject matter.

Table 5. Major influences for first-year students in choosing physics or astronomy as their academic specialty, 1997-98.

	US Citizen		Foreign Citizen	
	Top 3 %	Most Important %	Top 3 %	Most Important %
Interest in the subject matter	96	78	96	76
College professor	56	7	39	5
Career prospects	47	3	37	2
High school teacher	33	5	46	7
Fellow students	21	2	30	1
Parents	19	1	31	6
Expected salary & benefits	12	0	10	1
Other	16	4	11	2

Note: The percentages in the "Top 3" columns represent how many students listed a particular influence as one of their three most important. The "Most Important" column is the percentage for those who listed that particular influence as the most important.

Source: AIP 1998 Graduate Student Report.

The number of graduate physics departments to which students applied varied somewhat by citizenship. For US citizens, the average number was 5, with only 6% applying to more than ten departments. For foreign students, the average number was 7.5, and 17% applied to more than ten departments. In considering these data, the reader should keep in mind that they are based on the students who received acceptances and entered a graduate program. Results may be quite different for students who applied to physics graduate programs but did not get in.

Perhaps because of their more restricted range of applications, US students on the whole received a higher percentage of acceptances then their foreign counterparts. Foreign students may be less familiar with the US university system and thus apply to a greater number of departments. These departments may include a greater number of more prestigious departments, where the admission standards are more stringent.

Students were also asked to rank the reasons why they ultimately chose their current institution. The general reputation of the department and the specific facilities which it can offer were two of the leading reasons given. For the astronomy students, with fewer institutions from which to choose, these two factors were even stronger. The location of the institution was another important influence, and it played a greater role in the choices of the US students than it did for foreign students. The amount of financial support received also played an important role in the selection process of students, especially those from other countries.

Enrolled Students

Overall, the first-year graduate students responding to the survey share many common characteristics. For example, 93% were enrolled at PhD-granting departments (data collected at the departmental level shows the proportion to be 88%), practically all students (97%) were enrolled as full-time students and 91% hoped to ultimately receive a PhD.

However some key differences do emerge when you divide the students by the type of department in which they enrolled (see **Table 6**). The students enrolled at institutions where a master's is the highest available degree were more likely to be US citizens and to be attending on a part-time basis. The proportion of women enrolled in master's-granting departments was greater than at the doctoral-granting departments, due in part to a strong presence of foreign women among the incoming students at these institutions in 1997-98. Interestingly, half of the students enrolling at the master's institutions aspired to transfer to another institution and eventually earn a physics or astronomy PhD.

Table 6. Characteristics of first-year physics and astronomy graduate students by highest degree awarded by the department, 1997-98.

	Institution Type	
	PhD-Granting %	Master's-Granting %
Study status		
Full-time	99	82
Part-time	1	18
Citizenship*		
US	48	65
Foreign	52	35
Sex*		
Male	81	76
Female	19	24
Highest physics / astronomy degree desired		
PhD	93	53
Master's	7	47

* Data from the AIP Survey of Enrollments and Degrees

Source: AIP 1998 Graduate Student Report.

Choosing a subfield and advisor are important steps for students entering a graduate program. Many students enter with an area of specialty already in mind and, as discussed earlier, may have chosen their current institution based on the department's reputation in that specific area. Toward the end of their first-year at their current institution, more than three-quarters of the students had chosen a subfield and 55% had selected an advisor. Of the students for whom the desired degree was a master's, 13% indicated that no area of physics specialization was required to receive their degree. **Table 7** lists the major subfields chosen by students who intended to

Table 7. Major subfields of first-year students enrolled in a physics or astronomy program who have plans to receive a PhD, 1997-98.

	Citizenship	
	US %	Foreign %
Undecided	22	24
Astronomy/Astrophysics	18	8
Particles and Fields	13	13
Condensed Matter	12	25
Atomic and Molecular	6	3
Nuclear	4	5
Optics/Photonics	4	4
Biophysics	4	2
Materials Science	3	3

Source: AIP 1998 Graduate Student Report.

get a PhD. Students intending to receive astrophysics degrees from a physics program and the students enrolled in an astronomy program are all listed in the field of astronomy/astrophysics.

With one major exception, the distribution of subfields is similar for both US and foreign citizens. US citizens are far more likely to be pursuing degrees in astronomy or astrophysics, while foreign citizens tend to be more concentrated in the field of condensed matter. At the end of their first year, a nearly equal proportion of both US and foreign citizens remained uncertain about the subfield in which they would concentrate their research.

Nearly 95% of first-year graduate students receive financial support. The source of support for first-year graduate students has traditionally come primarily from teaching assistantships. **Table 8** shows that research assistantships and fellowships are more common at larger, more research-intensive doctoral-granting departments than at departments offering a master's as their highest degree.

Table 8. Primary sources of support by highest degree of department enrolled for first-year physics and astronomy graduate students, 1997-98.

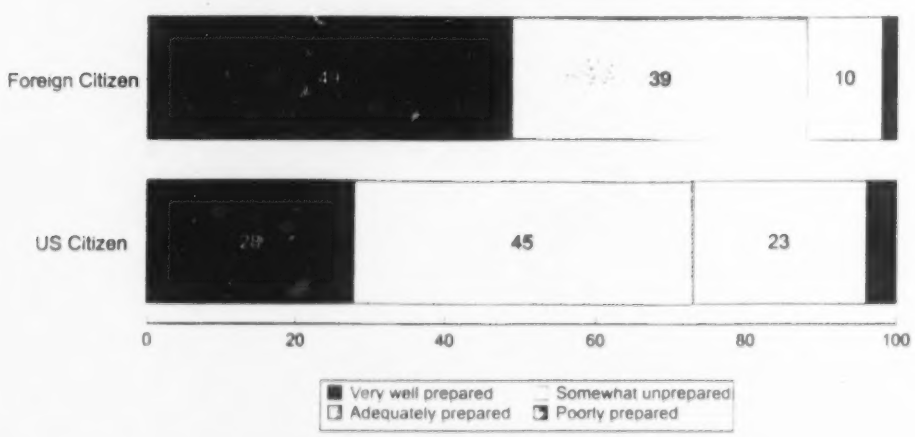
	PhD-Granting %	Master's-Granting %
Teaching assistantship	61	72
Research assistantship	15	9
Fellowship	18	7
Savings or loans	2	9
Non-Dept. employment	1	2
Other	3	2
	100%	100%

Note: Table only includes full-time enrolled students.

Source: AIP 1998 Graduate Student Report.

Sources of support varied according to the student's personal background and characteristics as well as department type. Not surprisingly, students who had already chosen an advisor were more likely to hold a research assistantship. Research assistantships were also more prevalent among US students in contrast to foreign students, and among male students compared to females.

Figure 2. Perception of undergraduate preparation for graduate school by citizenship for first-year physics and astronomy graduate students, 1997-98.



Source: AIP 1998 Graduate Student Report.

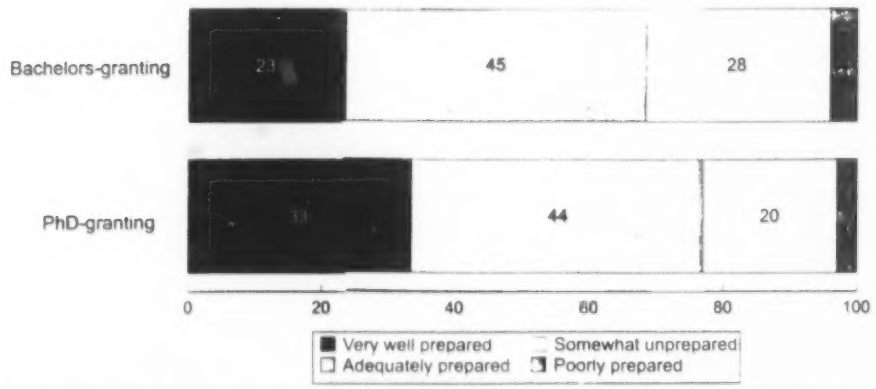
Students who were pursuing a master's as their highest degree, whether at a PhD-granting or a master's-granting department, were more likely to rely on personal funds or non-departmental employment to support their graduate education, as were students enrolled on a part-time basis.

Students were asked how well their undergraduate education had prepared them for graduate study in physics or astronomy. Overall, from the vantage point of nearly a year of graduate school, the majority (81%) felt they were adequately or well prepared, while 16% felt they were somewhat under prepared and only 3% felt they were poorly prepared. Entering students with undergraduate degree in subjects other than physics generally felt less prepared than those with a physics bachelor's. Additional differences in perceived preparedness related to such aspects of student background as citizenship, type of undergraduate institution and gender.

Figure 2 illustrates that first-year US students felt less prepared than their foreign counterparts. Much of this difference may lie in the differences in the undergraduate education structure of different countries. As mentioned earlier, we estimate that over half of the foreign students entering US graduate physics and astronomy programs have more than just the equivalent of a US bachelor's degree. Also, the heightened sense of preparedness of the foreign students may be related to the selection and self-selection of the students who come from abroad to study graduate-level physics and astronomy in the US.

The type of department from which a student earned their undergraduate degree also seems to have a modest influence on their perception of preparedness. **Figure 3** includes only US citizens who received a bachelor's degree in physics or astronomy from a US institution. One-third of the students earning their undergraduate degrees at the four-year colleges felt under-prepared, compared to a quarter of the students receiving their degree from doctoral-granting departments.

Figure 3. Perception of undergraduate preparation by type of undergraduate department for first-year US physics and astronomy graduate students with an undergraduate degree in physics, 1997-98.



Note: Students receiving physics bachelor's degrees from master's-granting institutions are not included in the figure due to low response from that population.

Source: AIP 1998 Graduate Student Report.

Other findings fit closely with this result. For example, in recent years, a substantially higher proportion of students from the doctoral-granting departments planned to pursue graduate study in physics than did their counterparts from schools with only undergraduate programs in physics.

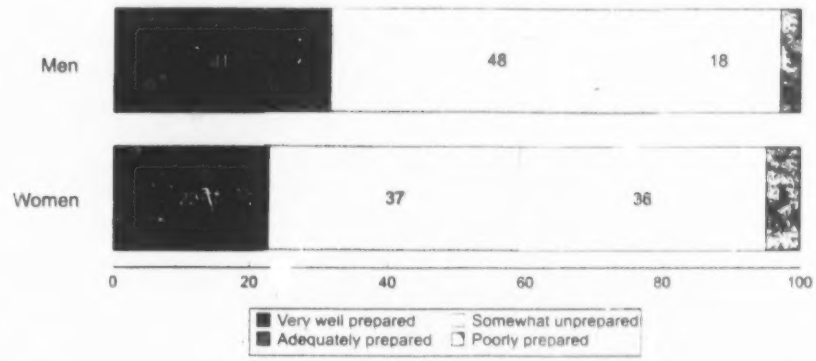
Thus, not only does a smaller proportion of students from undergraduate institutions go onto graduate study in physics, but the ones who do feel less prepared. It is not clear whether the greater research orientation at doctoral-granting departments prepares students better for the academic demands of graduate study, or whether such departments attract more highly prepared and more academically-orientated undergraduates in the first place, or a combination of both.

Another area where a difference in perceived preparation for graduate study emerges is gender. **Figure 4**, which compares perceived preparedness by gender, is limited to only US citizens who received a physics bachelor's degree from US institutions. The data show that women are twice as likely as men to feel either poorly or only somewhat unprepared for graduate school. The exact causes of this difference cannot be discerned from the current survey data.

THE FUTURE

The vast majority of the students (92%) anticipated continuing with their graduate studies next year at the department that they were currently attending. Two percent of the respondents said they planned to switch to another graduate discipline. This group consisted mostly of foreign citizens switching to engineering. An additional 5% indicated they were staying in the field of physics but switching to a different department. Interestingly, about half of this group were German citizens returning to Germany after completing a one year student exchange program. The other half were a mix of foreign and US students switching to a different US physics department. The remaining 1% of the non-continuing students indicated that they were leaving graduate studies altogether. It is important to keep in mind that the questionnaire was mailed to students near the end of the academic year. The actual first-year student attrition is estimated to be higher, as students who left their department during their first semester were unlikely to have received or responded to the survey.

Figure 4. Perception of undergraduate preparation by gender for first-year US physics and astronomy graduate students with an undergraduate degree in physics, 1997-98.



Source: AIP 1998 Graduate Student Report.

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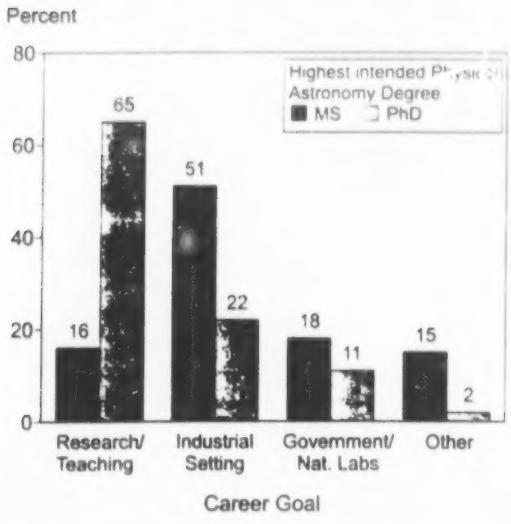
Students were asked to describe their long-term career goals. In general, the overall career goals of US and foreign citizens were very similar. However, because it is not clear from the data whether the foreign students intend to pursue careers in the US or abroad, the discussion and figures concerning long term career goals will include only the US citizens. It also excludes the 13% of the US students who indicated that they were undecided about their career goals.

The difference in intended career for those aiming for master's versus a doctorate is, of course, strongly related to the structure of the job market for those degrees (see **Figure 5**). About half of the students aspiring to a master's degree anticipate working in the private sector, which traditionally hires the bulk of new physics master's recipients. This contrasts sharply with the aspirations of students working towards a PhD, of whom two-thirds are hoping for an academic position at a college or university.

There were significant differences in long-term career goals of US students pursuing a PhD at astronomy departments versus those enrolled at physics departments. Only 15% of the astronomy doctoral students were planning for careers outside academia, whereas 37% of the physics doctoral students had similar career goals. This probably reflects, to a large extent, the greater range of career options that are available to physicists than astronomers in the industrial sector.

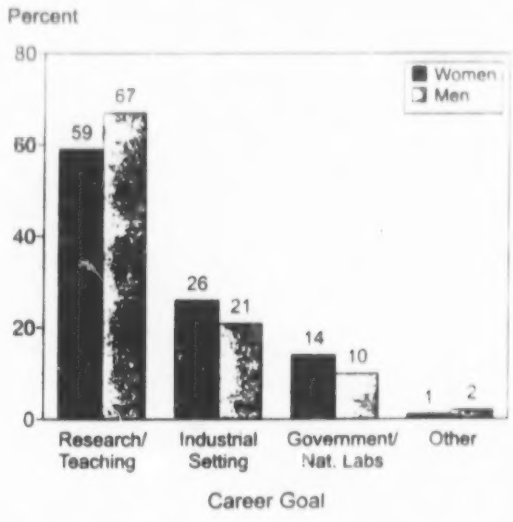
Long term career goal aspirations for men and women are fairly similar. Focusing on US citizens pursuing a PhD, **Figure 6**, shows that men are slightly more likely to aspire to careers in academia, whereas women tend a bit more toward governmental and industrial positions. On the other hand women were almost twice as likely as men to have indefinite career goals at this early phase of their graduate career. For the women, 21% did not have definite career goals whereas for the men it was only 12%.

Figure 5. Career goals by intended highest degree of first-year US physics and astronomy graduate students, 1997-98.



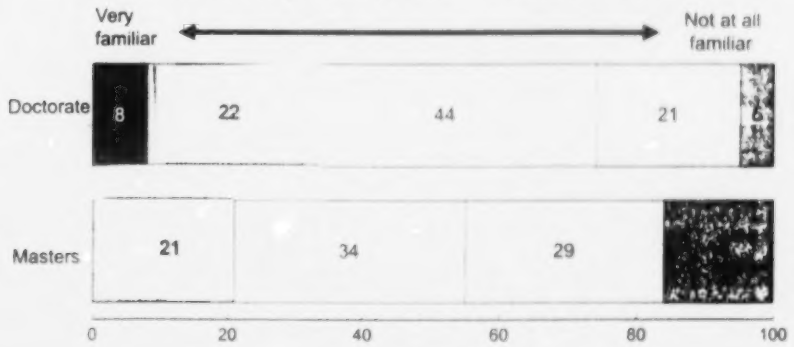
Source: AIP 1998 Graduate Student Report.

Figure 6. Career goals by gender of first-year US physics and astronomy graduate students, 1997-98.



Source: AIP 1998 Graduate Student Report.

Figure 7. Job market familiarity by highest intended physics/astronomy degree of first-year US physics and astronomy graduate students, 1997-98.



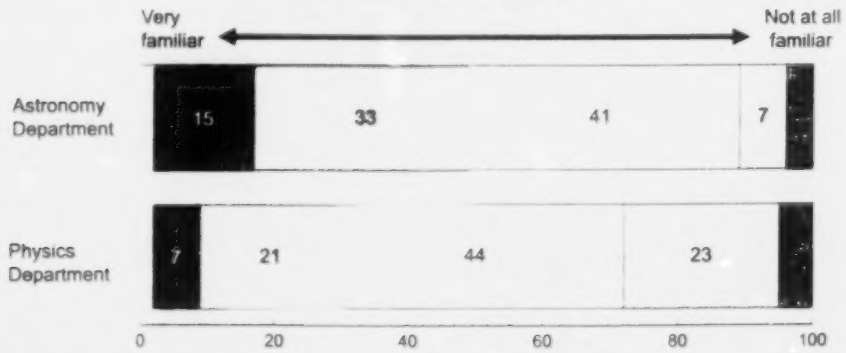
Source: AIP 1998 Graduate Student Report.

Finally students were asked about their familiarity with the job market. Again, this discussion is restricted to US students and, for the most part, the US labor market.

Students who indicated that they were aspiring to eventually obtain a PhD were more likely than the students studying for a master's to say that they were familiar with the job market (see **Figure 7**). Indeed, not one of the master's degree hopefuls indicated that they felt very familiar with the job market. This is likely a result of an historical pattern in which employment possibilities for physics PhDs are generally well defined and better known to physics graduate students and faculty. The employment opportunities available for master's recipient are far more diverse and far less familiar to students and professors.

Students studying for astronomy and astrophysics PhDs at astronomy departments indicated a greater familiarity with their potential job market than did their physics student counterparts (see **Figure 8**). Again, this is most likely related to the typical employment structure characterizing the two disciplines, with physicists having a more varied and thus less predictable employment opportunities.

Figure 8. Job market familiarity by department type of entering US physics and astronomy students who are pursuing a PhD, 1997-98.



Source: AIP 1998 Graduate Student Report.